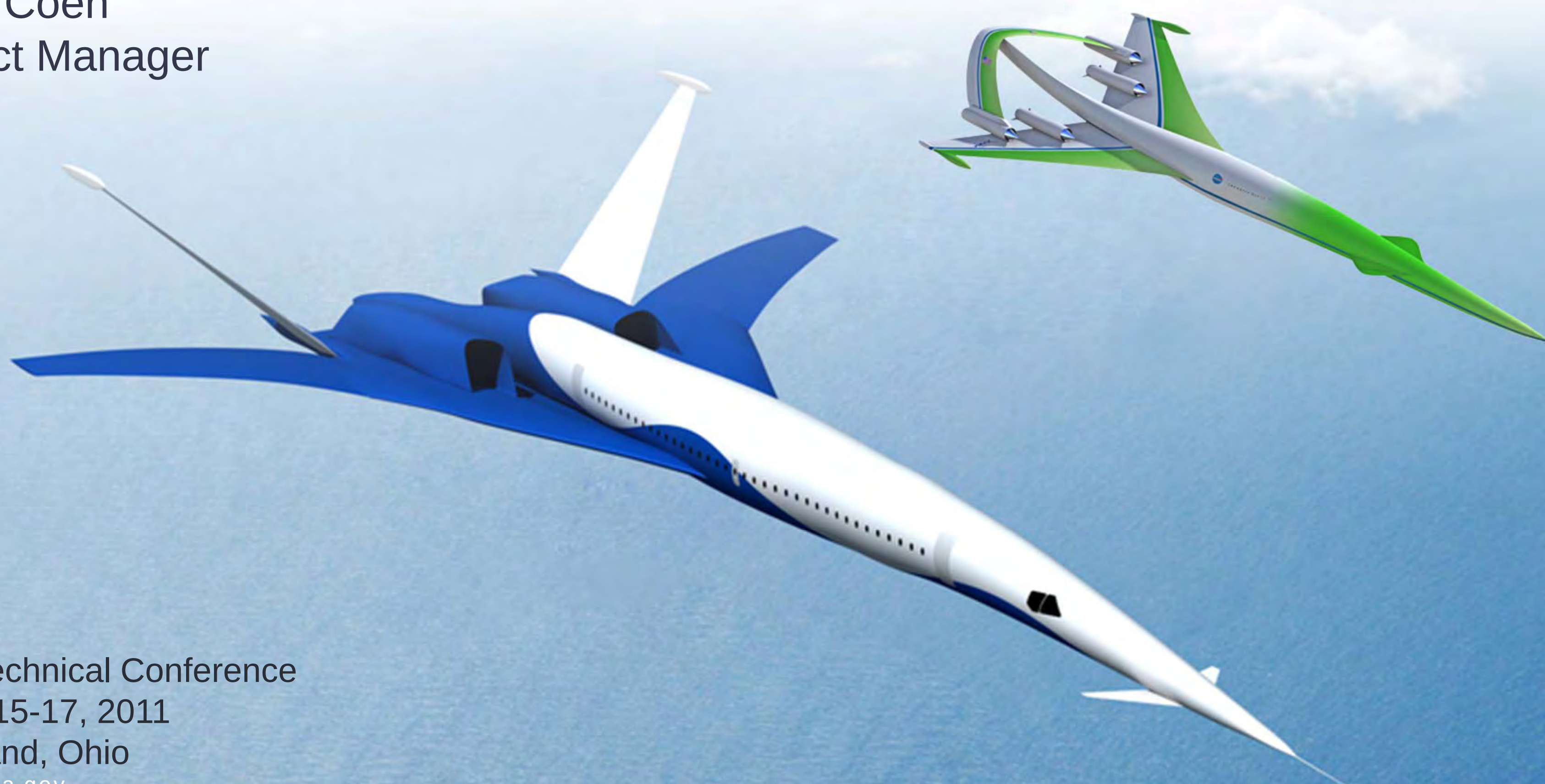
National Aeronautics and Space Administration

Fundamental Aeronautics Program

Supersonics Project

Project Overview
Peter Coen
Project Manager



2011 Technical Conference
March 15-17, 2011
Cleveland, Ohio

www.nasa.gov

Presentation Outline

- Overview
  - Project principles and strategy
  - Technical Challenges
  - Assessment of goals and technology portfolio
- Technical Highlights
- NRAs & Partnerships
- Upcoming Activities
- Summary

Guiding Principles and Motivation

Fundamental Aeronautics Program Overview

Overarching goal:

To achieve technological capabilities necessary to overcome national challenges in air transportation including reduced noise, emissions, and fuel consumption, increased mobility through a faster means of transportation, and the ability to ascend/ descend at very high speeds through atmospheres.

Subsonic Fixed Wing (SFW)

Enable revolutionary energy efficiency improvements of subsonic/ transonic transport aircraft that dramatic reduce harmful emissions and noise for sustained growth of the air transportation system.

Subsonic Rotary Wing (SRW)

Radically improve the transportation system using rotary wing vehicles by increasing speed, range, and payload while decreasing noise and emissions.

Supersonics

Eliminate environmental and performance barriers that prevent practical supersonic vehicles (cruise efficiency, noise and emissions, performance, boom acceptability).

Hypersonics

Enable airbreathing access to space and high mass entry, descent, and landing into planetary atmospheres .

9

National Aeronautics Policy & Plan; NASA Strategic Plan

- National Aeronautics R&D Policy (Dec 2006) and Plan (Dec 2007, Feb 2010),
  - "Mobility through the air is vital…"
  - "Aviation is vital to national security and homeland defense"
  - "Assuring energy availability and efficiency is central…" and "The environment must be protected…"
- NASA Strategic Plan
  - Strategic Goal 4: "Advance aeronautics research for societal benefit"
- NextGen: The Next Generation Air Transportation System
  - Joint Planning Development Office (JPDO), Vision 100 (2003)
  - Revolutionary transformation of the airspace, the vehicles that fly in it, and their operations, safety, and environmental impact

7

Research Prioritization 2

Leadership Teams prioritize and make decisions with internal and external inputs subject to criteria and constraints using appropriate tools/ methodology.

Top Down

⇩

- Program Goals
- Project Goals and Objectives
- Technical Challenges
- Research Needs for Each Technical Challenge
- Technical Content of Projects

⇧

Bottom Up

NRC Decadal Study - 60+ Subject Matter Experts

Next Generation, Integrated Work Plan

DOD, DOE

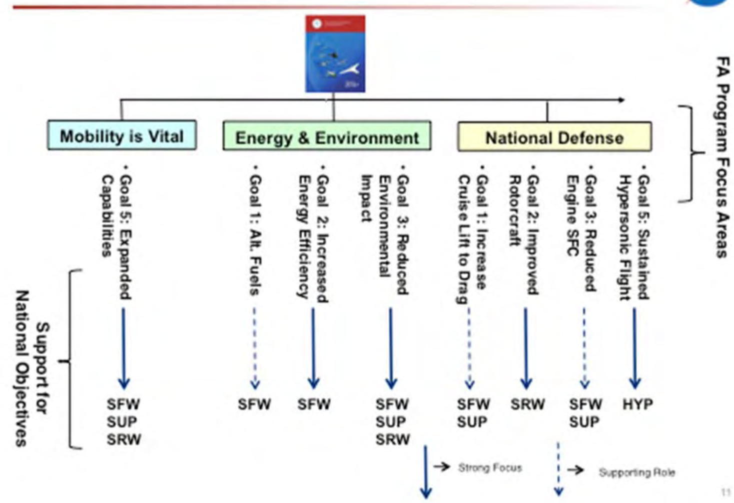
Other NRC Studies

Independent Review Panels

Stakeholder Input

- NASA Centers, other government laboratories, industry, universities via visits, meetings, etc.
- Planning workshops, RFI's, Annual Meetings, annual NRA reviews, other reviews
- Results, recommendations & systems studies from current projects.

Flow-down from National Plan



11

Project Overarching Goal & Focus

Overall Project Goal:

Tool and technology development that addresses challenges in the broad spectrum of supersonic flight

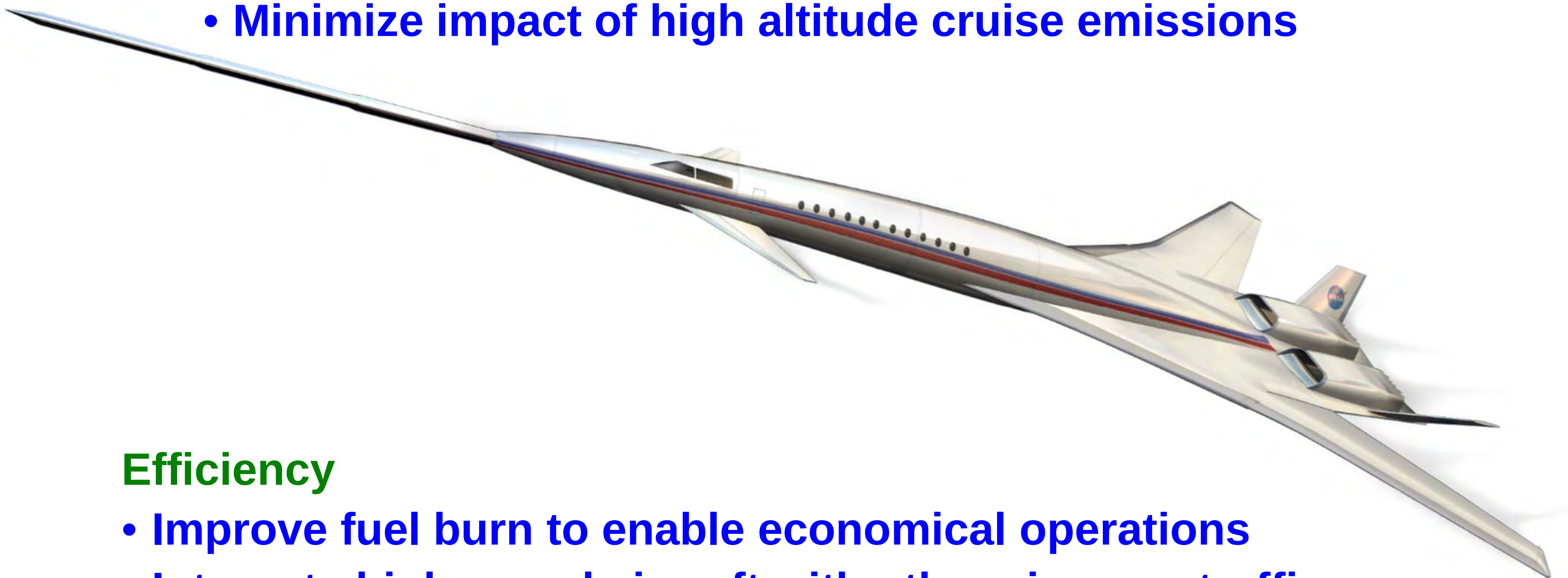
Focus Area:

Overcoming the technology barriers to practical civil supersonic airliners

Overcoming the Barriers

Environmental

- Reduce sonic boom noise to allow supersonic overland flight
- Noise levels acceptable for airport communities
- Minimize impact of high altitude cruise emissions



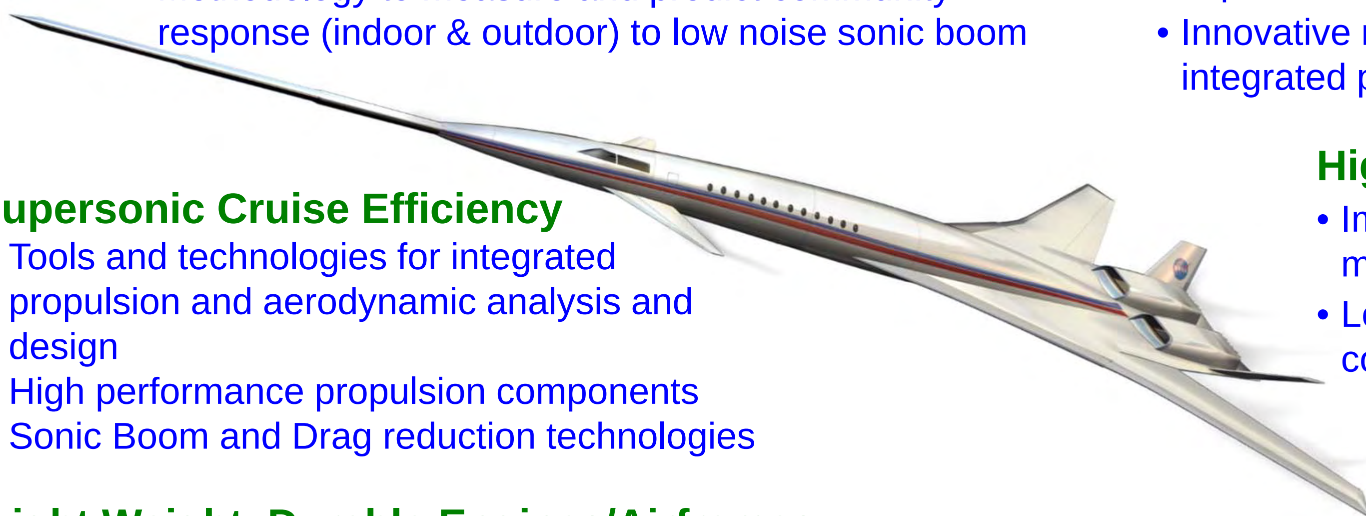
Efficiency

- Improve fuel burn to enable economical operations
- Integrate high speed aircraft with other airspace traffic

Supersonic Project Technical Challenges

Sonic Boom Community Response
- Realistic models for propagation of low noise sonic boom
- Methodology to measure and predict community response (indoor & outdoor) to low noise sonic boom

Airport Noise
- Improved prediction techniques for supersonic propulsion noise
- Innovative nozzle designs for highly integrated propulsion systems



Supersonic Cruise Efficiency
- Tools and technologies for integrated propulsion and aerodynamic analysis and design
- High performance propulsion components
- Sonic Boom and Drag reduction technologies

High Altitude Emissions
- Improved analysis and measurement tools
- Low emissions combustor concepts

Light Weight, Durable Engines/Airframes
- Materials, test and analysis methods for airframe and engine efficiency, durability and damage tolerance

Integrated Multi-Discipline System Design
- Develop improved system level analysis and design capabilities, achieving low sonic boom and high performance
- Integrate discipline level tools into the vehicle level analysis models.
- Develop innovative, integrated concept designs and assess technology needs and impacts

Aeroservoelastic Analysis and Design
- ASE/flight dynamic and propulsion analysis and design tool development and validation
- Include propulsion effects: APSE analysis and design tools

- **Integration of Supersonic Aircraft in NextGen System (with Airspace Program)**
  - Determine the characteristics for an airspace system that enables supersonic aircraft to utilize their full capabilities

Investment Strategy

- Primary focus on Technical Challenges
  - Foundational, Discipline and Multidiscipline Level activities
  - Identify and address solutions "at the seams" between conventional disciplines
- Pursue multidiscipline and flight validation where resources permit
- Majority of effort is supersonics unique, overlapping with other projects where strong synergy exists
- Incorporate an element of long term foundational research with potential high payoffs
  - May not align with a particular Tech Challenge
- Develop facilities and measurement capabilities for unique supersonic problems
- Maximize leverage of investment and partnership with external communities
- Maintain technical excellence and workforce stability

Project Organization Aligns with Tech Challenges

PROJECT LEVEL

- Sub Projects Organized By Technical Challenges
- Technical Leads for Sub-Project providing overall technical direction and oversight
- Deputy by Centers for Execution Oversight and Project Integration

Project Manager: Peter Coen (LaRC)
Deputy Project Manager: Kaz Civinskas (GRC)
Project Scientist: Dr. Lou Povinelli (GRC)

DPM For ARC: Don Durston	DPM for DFRC: Tom Jones	DPM for GRC: Vacant APM Clayton Meyers	DPM for LaRC: Dave Richwine

SUB-PROJECT LEVEL

	ARC	DFRC	GRC	LaRC
SIA: Lori Ozoroski (LaRC), Clayton Meyers (GRC)	**Systems Integration & Assessment**		**Systems Integration & Assessment**	**Systems Integration & Assessment**
SCE-P: Ray Castner (GRC), SCE-A: Linda Bangert (LaRC)	**Supersonic Cruise Efficiency - Airframe**		**Supersonic Cruise Eff. - Propulsion**	**Supersonic Cruise Efficiency - Airframe**
LDE: Dale Hopkins (GRC) LDA: Dr. Phil Bogert (LaRC)			**Light Weight, Durable Engines**	**Light Weight, Durable Airframes**
Airport Noise: Dr. James Bridges (GRC)			**Propulsion Acoustics**	**Acoustics Integration**
Sonic Boom Comm. Resp.: Dr. Alexandra Loubeau (LaRC)		**Sonic Boom Flt. Res.**		**Sonic Boom Modeling**
High Altitude Emissions: Dr. Dan Bulzan (GRC)			**High Altitude Emissions**	
Aeroservoelasticity: Dr. Walt Silva (LaRC)		**Aeroelasticity**	**Aero-Propulso-Servo-Elasticity (APSE)**	**Aeroelasticity, APSE**
Flight Research & Validation: Dan Banks (DFRC)	**Flt. Res. Tools**	**FRV**		**External Vision Sys**
Center in () is Tech. Lead	Resource Analyst (RA): Christian Aguilar	Resource Analyst (RA): Susan Moreno	Lead RA: Mary Neuzil NRA Manager: Vacant	RA: Pamela Stacy Project Scheduler: Leslie Letzinger

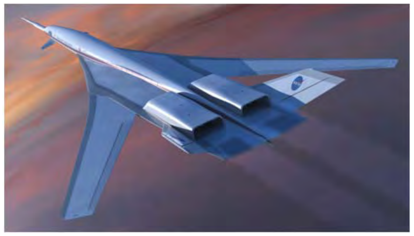
Technology Challenge Goals

Balanced Goals for Practical Civil Supersonic Aircraft (Technology Available)	N+1 Supersonic Business Class Aircraft (2015)	N+2 Small Supersonic Airliner (2020)	N+3 Efficient Multi-Mach Aircraft (Beyond 2030)
Design Goals			
Cruise Speed	Mach 1.6-1.8	Mach 1.6 -1.8	Mach 1.3 - 2.0
Range (n.mi.)	4000	4000	4000 - 5500
Payload (passengers)	6-20	35-70	100 - 200
Environmental Goals			
Sonic Boom	65-70 PLdB	65-70 PldB	65-70 PLdB Low Boom flight 75-80 PldB Overwater flight
Airport Noise (cum below stage 4)	Meet with Margin	10 EPNdB	10-20 EPNdB
Cruise Emissions (Cruise NOx g/kg of fuel)	Equivalent to current Subsonic	< 10	< 5 & particulate and water vapor mitigation
Efficiency Goals			
Fuel Efficiency (pass-miles per lb of fuel)	1.0	3.0	3.5 – 4.5

- NASA defined an initial set of design parameters and performance levels for practical supersonic airliners in the near, mid and far term time frames
- Systems Studies have been used to determine if these goals are valid and achievable

N+1 "Conventional"

N+2 Small Supersonic Airliner



N+3 Efficient, Multi Mach Aircraft

Current Project Strategy and Direction

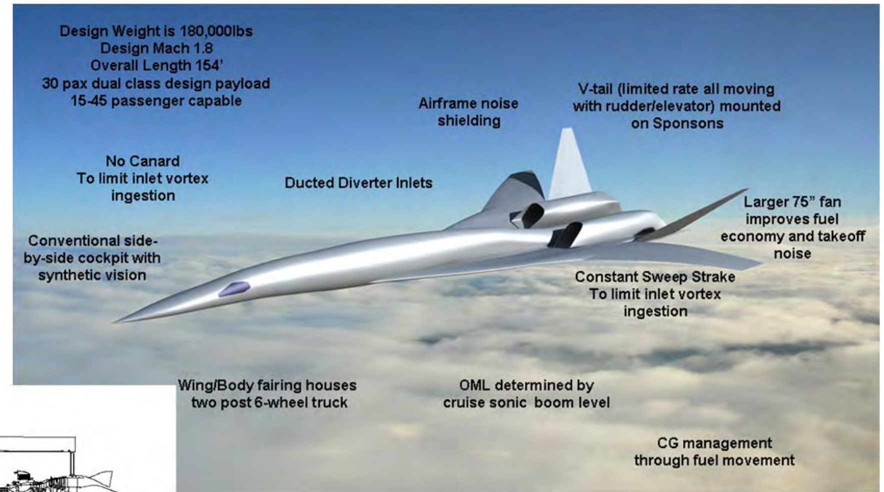
- Assess and update technology challenge goals through concept development and systems analysis
- Assess technology performance required to achieve tech challenge goals
- Identify gaps in current technology portfolio
- Focus research effort on the key Technology Challenge: Reduce sonic boom noise to allow supersonic overland flight
  - Design tools and techniques for aircraft with very low sonic boom noise
    - Supersonic Cruise Efficiency: High fidelity tools
    - System Level Design: Multi-fidelity, Multidiscipline design framework and tools for low boom/low drag design
  - Understand reaction to sonic booms from the above designs & lay the groundwork for noise based sonic boom standards
    - Sonic Boom Community Response: Sonic boom propagation, transmission into structures and indoor and outdoor human response

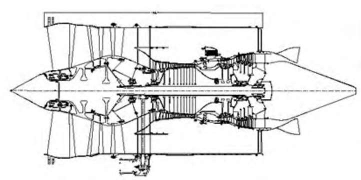
Assessing Goals and Portfolio

- FY06 Planning established initial goals and research portfolio
  - Many sources of quality input
- New assessment was deemed valuable to bring project up to date
  - Current market
  - New technology
  - New configuration direction (Boom constrained)
  - NextGen development
- Baseline configuration needed
- Recommendation from previous review panels
- Two studies conducted, completed in FY09 & 10

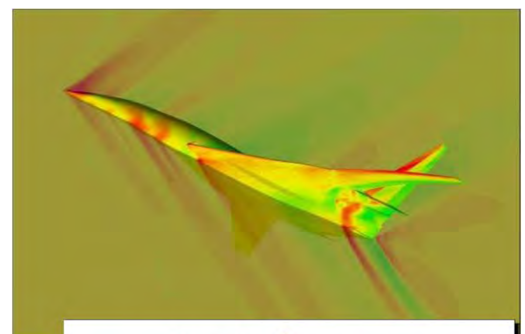
Assessing Goals and Portfolio
N+2 System Study

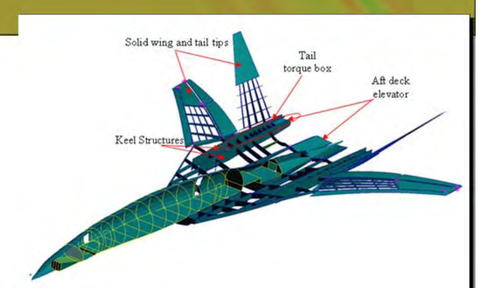
- Boeing, Rolls-Royce, Pratt & Whitney, and Georgia Tech team effort
- Baseline concept for the N+2 timeframe developed for a **balanced set of requirements**
- Key Results
  - NASA N+2 Goals difficult to achieve in 2020
  - Integrated propulsion cycle design process demonstrated
    - Includes cycle parameters in vehicle optimization
  - Configuration shaping for low boom is a key technology
- Configuration is being used as baseline in many SUP research efforts





	NASA N+2 Small Supersonic Airliner (2020)	Systems Study Results
Environmental Goals		
Sonic Boom	65 – 70 PLdB	90 PLdB
Airport Noise (cum below stage 4)	– 10 EPNdB	– 5 EPNdB
Cruise Emissions (g/kg fuel)	< 10	Not evaluated
Performance Goals		
Cruise Speed	Mach 1.6 - 1.8	Mach 1.6
Range	4000 nm	3800 nm
Payload	35 – 70 pax	30 pax
Fuel Efficiency (pax-nm/lb-fuel)	>3.0	1.57





Assessing Goals and Portfolio
N+3 Concept and Technology Studies

PROBLEM

National need to gain understanding of advanced airframe and propulsion concepts, as well as corresponding enabling technologies, that address the many challenges for commercial aircraft entering service in the 2030-35 timeframe (N+3).

OBJECTIVE

Stimulate thinking to create revolutionary aircraft solutions that dramatically improve the performance, environmental impact and operational flexibility of future aircraft. Determine high payoff technologies and research opportunities that will enable these solutions.

APPROACH

NRA-competed awards for N+3 Concept Studies selected 6 industry/university teams. 4 teams addressed subsonic transports, and 2 studied supersonic transports.

Lockheed Concept Vehicle

Boeing Concept Vehicle

Balanced Goals for Practical Civil Supersonic Aircraft (Technology Available)	N+1 Supersonic Business Class Aircraft (2015)	N+2 Small Supersonic Airliner (2020)	N+3 Efficient Multi-Mach Aircraft (Beyond 2030)
Design Goals			
Cruise Speed	Mach 1.6-1.8	Mach 1.6 -1.8	Mach 1.3 - 2.0
Range (n.mi.)	4000	4000	4000 - 5500
Payload (passengers)	6-20	35-70	100 - 200
Environmental Goals			
Sonic Boom	65-70 PLdB	65-70 PldB	65-70 PLdB Low Boom flight 75-80 PldB Overwater flight
Airport Noise (cum below stage 4)	Meet with Margin	10 EPNdB	10-20 EPNdB
Cruise Emissions (Cruise NOx g/kg of fuel)	Equivalent to current Subsonic	< 10	< 5 & particulate and water vapor mitigation
Efficiency Goals			
Fuel Efficiency (pass-miles per lb of fuel)	1.0	3.0	3.5 – 4.5

N+3 Airframe & Propulsion Technologies

- *Prioritized Technologies from N+3 System Studies align well with the SUP research portfolio*
- *Detailed roadmaps were used to guide several adjustments in out-year plans*

Airframe Technologies
Lockheed and Boeing N+3 Studies

- *Prioritized Airframe Technologies from N+3 System Studies align well with the SUP research portfolio*
- *Detailed roadmaps were used to guide several adjustments in out-year plans*

Lockheed Priorities

1. Boom Shaping (tools/methods)
2. CFD-Based MDAO (tools/ methods)
3. Distributed Roughness w/ Plasma (Laminar Flow)
4. Low-Boom Violation Cueing (Pilot Situational Awareness)
5. Boom/Noise Pre-Planning (Pilot Situational Awareness)
6. Integrated Structural Analysis (tools/methods)
7. Lift Distribution Control (Adaptive Geometry)
8. Jet Exhaust Manipulation (Plasma)
9. Inlet Flow Control (Adaptive Geometry)

Common Priorities

1. Low-Boom Shaping Design & Signature Control
2. Supersonic Laminar Flow
3. Integrated Structural Design & APSE
4. CFD-Based MDAO for aero-efficiency
5. Multi-functional & adaptive structures
6. Airport noise mitigation
7. Aircraft systems & controls
8. High-Lift & Lift distribution/control

Uncommon Outliers
SFW synergy potential
DoD synergy potential
In Current Portfolio

Boeing Priorities

1. Low-Boom /Low-Drag MDO (tools/ methods)
2. Reliability-based Design & Cert., Structural health mgmt.
3. Laminar Flow
4. Noise shielding Integration (inlet
5. Low impact, low liners
6. APSE, active Gl suppression
7. Sonic Boom act
8. Aircraft systems monitoring/contr
9. Low-speed/High Control/syntheti
10. Energy systems
11. Multi-functional tailoring
12. Airframe Materi

Propulsion Technologies
Lockheed and Boeing N+3 Studies

Prioritized Propulsion Technologies from N+3 System Studies also align well with the SUP research portfolio

RR-LW Priorities

1. 3-stream Var. Cycle
2. Adv. Var. Fan
3. Component efficiency, unsteady aero
4. CVC/wave rotor combustor
5. CMC turbine blades & vanes
6. CCA HX
7. Hybrid turbomachinery disk
8. Staged ejector-nozzle
9. 3rd Stream IVP jet acoustics
10. Intercooled compressor
11. Low-profile/embedded C&A
12. Nozzle materials: SMAs (variability), porous Ceramics (liners)
13. Var. area turbine

Common Priorities

1. Multi-stream Var. Cycle
2. Adv. Var. Fan (aero, structure, acoustics)
3. IVP nozzle & jet noise
4. CMC turbine blades & vanes
5. CCA HX
6. CVC-type combustor
7. Var. area turbine
8. Variable area mixers/nozzles (materials & mech. design)

Uncommon Outliers
SFW synergy potential
In Current Portfolio

DoD synergy potential for all technologies

GE Priorities

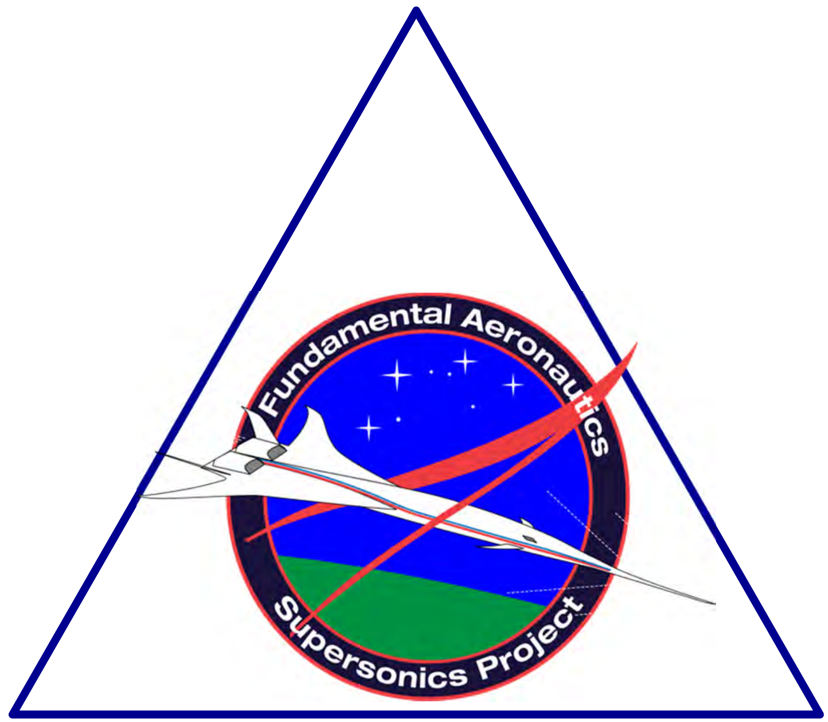
1. 3-stream FLADE Var. Cycle
2. 3rd Stream IVP jet acoustics w. Fluid Acoustic Shield & Chevrons
3. Adv. Var. Fan (aero, structure, acoustics)
4. Chem. Reaction modeling
5. Duct-integrated mini-burner
6. CCA HX (using FLADE stream, to HPT R1)
7. Var. area turbine
8. CMC turbine blades & vanes
9. Variable area mixers/nozzles
10. CVC combustor
11. Active jet noise control

Pratt & Whitney Priorities

1. Tandem fan Var. Cycle (F135-based)
2. TB2 - Adv. On-incidence fan w. var. pitch, camber, IGV/EGV vortexing
3. TB1 - Hot section materials & 2nd system
4. TB1 - Var. area turbines
5. TB2 - Var. mixer/nozzles & inlet/ducts

Key Elements of Research Strategy

In house research maximizing the use of
NASA's skilled workforce and unique facilities



Sponsored research with the best minds in the US University and Industry communities

Research Partnerships with organizations with similar goals (OGA, US Industry, International)

Key APG Milestones Successfully Completed

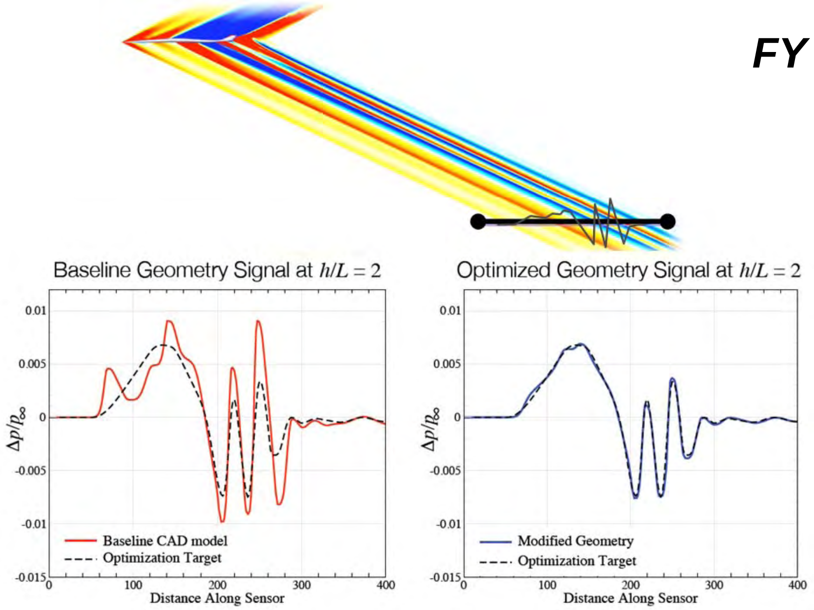
Adjoint-Based Design for Configuration Shaping — *FY 09*

Objective:

Apply nonlinear aero (CFD) and knowledge of desired near field pressures to shape configuration geometry

Significance:

- Low boom designs can be created based on non-linear flow solution data
  - Can mitigate or exploit flow features to create unique solutions



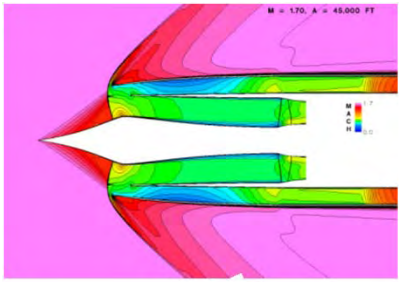
Computational Modeling of Integrated Inlet & Fan Performance — *FY 10*

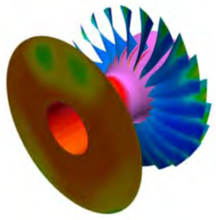
Objective:

- Understand coupling of inlet and fan flowfields in unconventional inlet shapes and potential effects on performance and stability

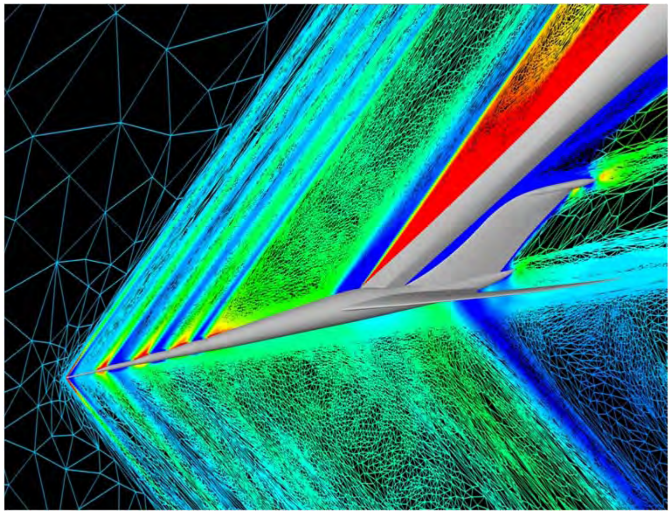
Significance

- New tools will enable the analysis and design of inlet/fan systems that achieve the levels of efficiency and sonic boom noise required for viable supersonic civil aircraft.
- Allow for the analysis of non traditional inlet shapes for highly integrated design of the next generation of supersonic aircraft

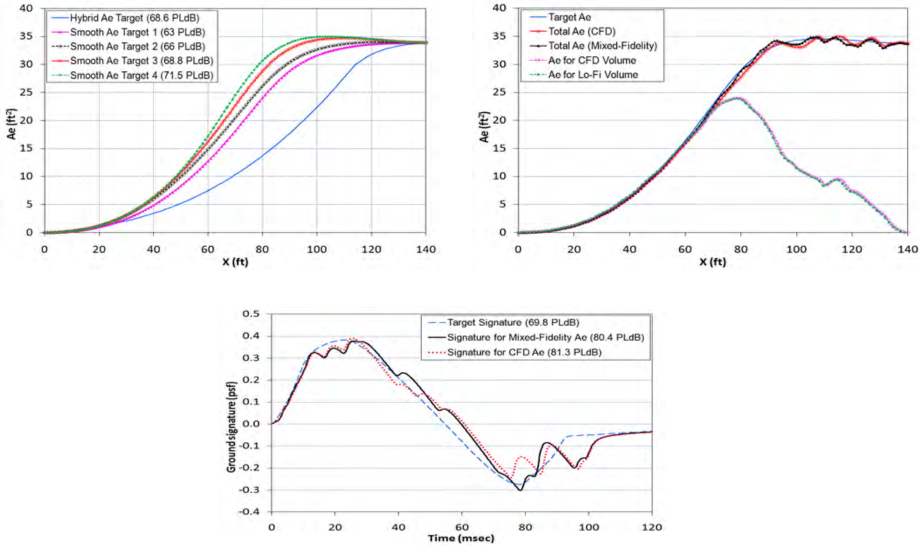




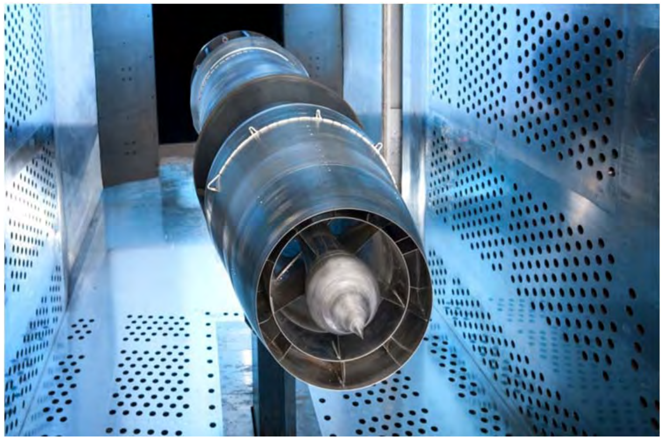
Key Research Successes in All Technical Challenge Areas
1 - Cruise Efficiency, Systems Level Design



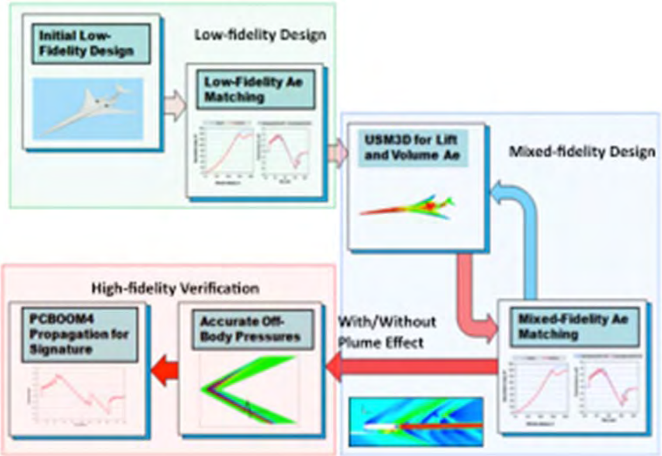
Grid Techniques & Solver Improvements for Boom Prediction



Target Signature and Vehicle Shape Design

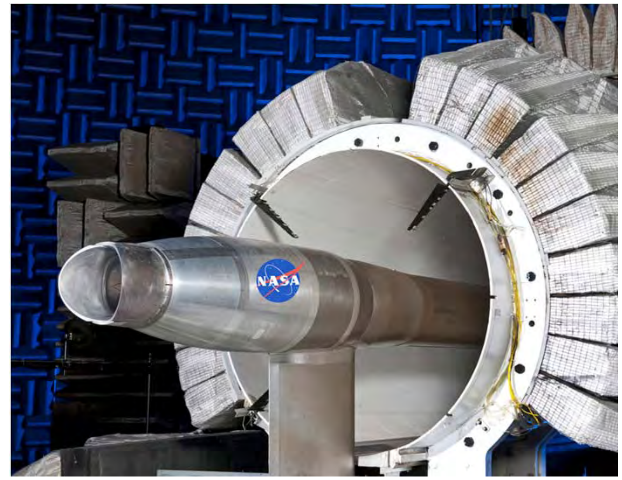


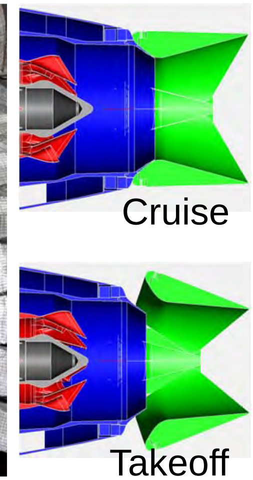
Low Sonic Boom Inlet Design & Test



Multi-Fidelity Design and Analysis Process

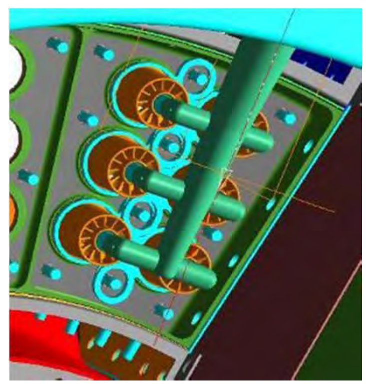
Key Research Successes in All Technical Challenge Areas
2 – Sonic Boom, Noise & Emissions

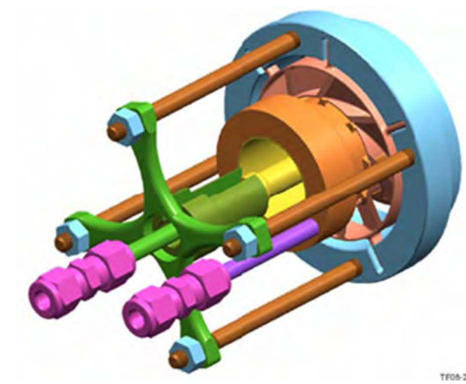




Highly Variable Cycle Nozzle
Test and Analysis

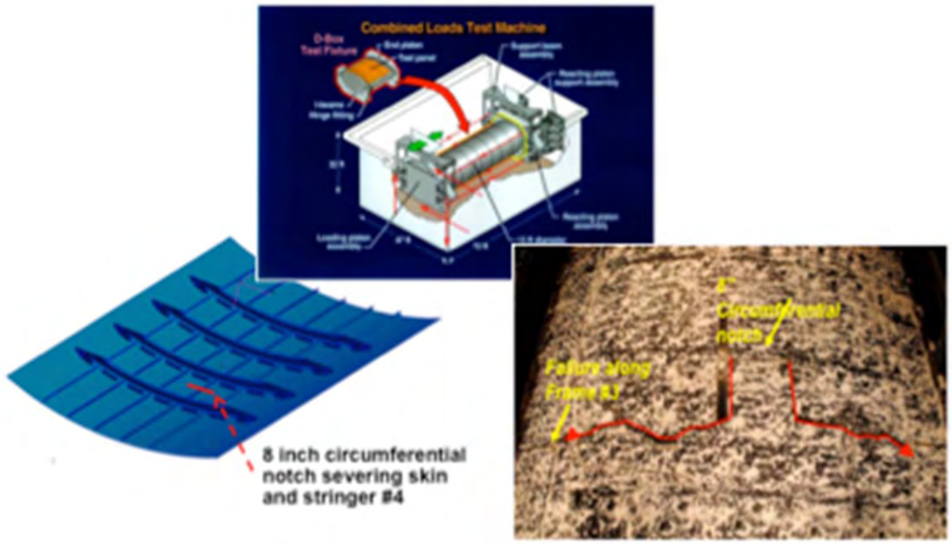
Indoor Sonic Boom Subjective Test
Facility Operational



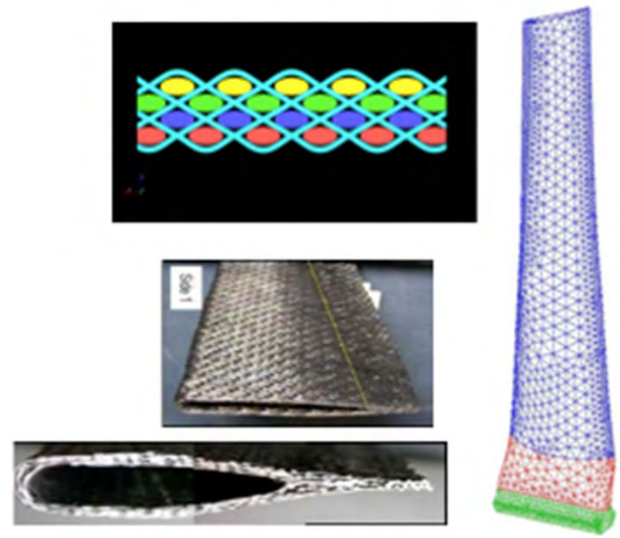


Low NO_x Combustor Concept
Development & Testing

Key Research Successes in All Technical Challenge Areas
3 – Lightweight, Durable Airframes & Engines, Aeroelasticity

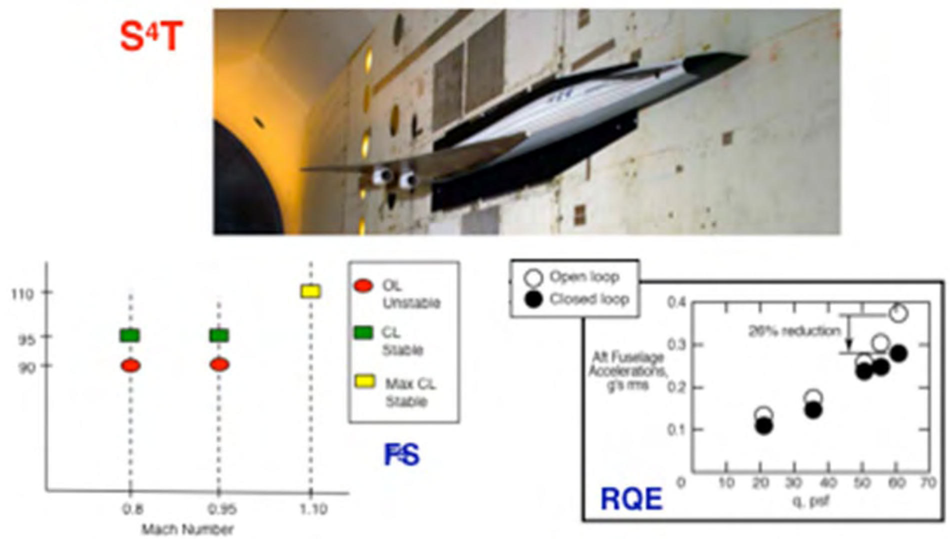


Progress Failure Analysis Validation



Ceramic Matrix Composite Components

Aeroelastic Control Law Development & Test



Key Research Successes in All Technical Challenge Areas
4 – Flight Research & Validation

Flight Component of Sonic Boom Research

Supersonic Boundary Layer Transition

F-15 Flowfield Calibration

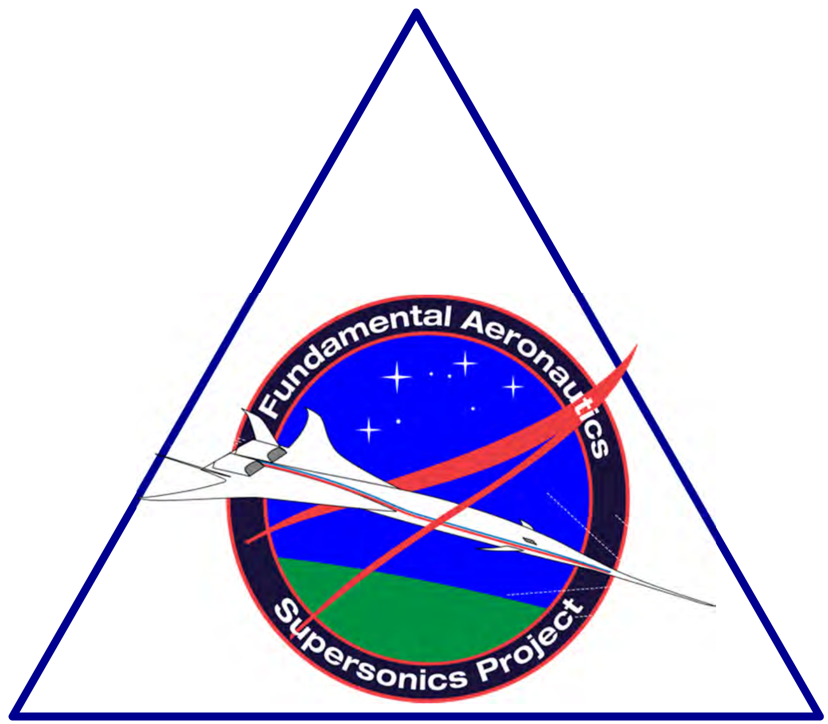
Motorglider Microphone Platform Development

Additional Investment in Supersonics: American Recovery and Reinvestment Act (ARRA)

- Project research content has benefited substantially from augmentation funding in past fiscal years
  - Facility and Measurement capability improvement
  - Optional NRA tasks and new NRA awards
  - Multi-Discipline systems validation
- 2009 ARRA investment has been used primarily to augment sonic boom related technical challenge research
  - Supersonic Cruise Efficiency
    - Sonic boom design validation (2 awards: Boeing and Lockheed Teams)
    - Validation wind tunnel tests
    - Large Scale Low Boom Inlet wind tunnel test (+ measurement hardware)
  - Sonic Boom Community Response
    - New NRA awards for community response pilot project and focus boom
  - Airport Noise
    - Wind tunnel testing of Supersonic Inlet & High Variable Cycle Nozzle

Key Elements of Research Strategy

In house research maximizing the use of
NASA's skilled workforce and unique facilities



Sponsored research with the best minds in the US University and Industry communities

Research Partnerships with organizations with similar goals (OGA, US Industry, International)

Supersonic NRA Investments

Tech Challenge	University		Other Non-Profit		Small Business		Other Industry	
	No.	$M	No.	$M	No.	$M	No.	$M
Sonic Boom Community Response *	3	1.011			1	0.264	5	1.924
Supersonic Cruise Efficiency *	11	10.458	1	1.998	1	1.519	3	5.902
Integrated Multi-Discipline System Design	2	1.983			1	1.211	3	5.998
Airport Noise	5	4.191					2	0.730
High Altitude Emissions	4	4.665	1	0.756			4	5.152
Light Weight Durable Engines/Airframes	10	5.891	1	0.943			3	1.070
Aeroservoelastic Analysis & Design					1	0.600	1	0.418
Flight Research & Validation					1	0.306		
Total	35	28.199	3	3.697	5	3.900	21	21.194

* Includes ARRA Funds

Recent and Planned NRA Solicitations		
Year	Solicitation Topics	Awards
2008	Light Wt, Durable Airframes, High Altitude Emission (Combustor Concepts)	4
2008	N+3 Concepts and Technologies for Supersonic Aircraft in 2035	2
2009	Concepts for Systems Validation (ARRA Funds)	2
2009	Sonic Community Response (Auralization, Community Response, Focusing)	4
2011	Broad Solicitation (all Tech Challenges)	TBD

NRA Impact on Project Tech Challenges

- SUP project philosophy stressed integration of NRA with Tech Challenge research
- Integration and impact of NRA investment has far exceeded expectations.
  - Innovative research results
  - Unique, effective research partnerships
  - Research and test hardware development
- Examples:

<u>Supersonic Cruise Efficiency</u>

- Notre Dame University, NASA Team Supersonic boundary layer transition suppression via distributed roughness
- UIUC, Gulfstream, NASA Team: Micro-ramp flow control for low boom supersonic inlets

<u>Sonic Boom Community response</u>

- Industry/University team address all aspects of community response

<u>High Altitude Emissions</u>

- Industry NASA team: Low emission combustor concept development and testing

<u>Light Weight, Durable Engines/Airframes</u>

- University, Industry NASA Team: Development and Validation of PFA tools
- University, Industry, Government Team: Ceramic composite components for jet engines

<u>Aeroelasticity</u>

- Industry NASA Team: Development and test of ASE control laws

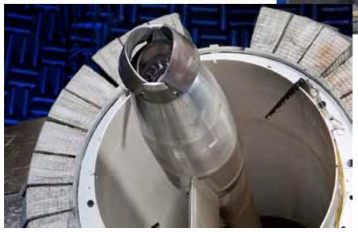
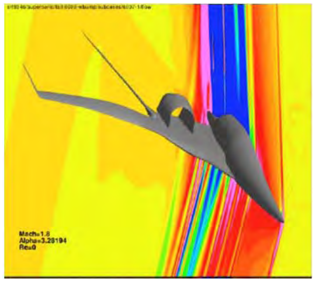
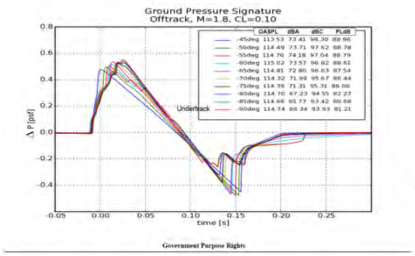
+ Many more

NRA Investment
System Level Validation of Low Boom Design

- Two large awards under NRA (May 2010)
  - Boeing
  - Lockheed (GE, Liberty Works subs)
  - Phase 1 runs through May 2011
- Principal objectives
  - Mature low boom design tools
  - Validate with wind tunnel tests in Ames 9x7 SWT
  - Include propulsion airframe interaction, inlet and nozzle effects
  - Validate noise reduction concepts
  - Improve model design and data measurement techniques
- Significant In-house involvement
  - Research Interaction
  - Wind Tunnel and other test facilities

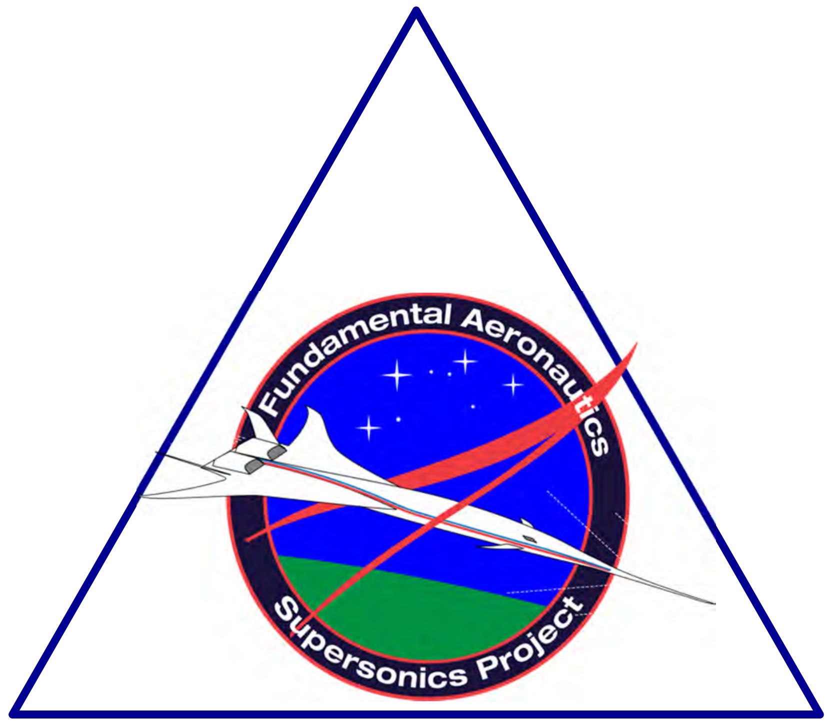




Key Elements of Research Strategy

In house research maximizing the use of
NASA's skilled workforce and unique facilities



Sponsored research with the best minds in the US University and Industry communities

Research Partnerships with organizations with similar goals (OGA, US Industry, International)

Partnerships

On-Going

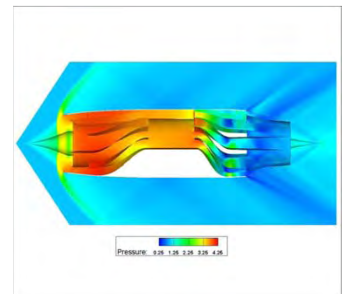
- FAA PARTNER Center of Excellence, Cooperatively pursue research supporting sonic boom standards development
- Japan Aerospace eXploration Agency (JAXA) – Sonic Boom Modeling
- Japan Aerospace eXploration Agency (JAXA) – Supersonic Boundary-Layer Transition
- Gulfstream Aerospace Corporation, Low Boom Experimental Vehicle (LBEV) Program, Annex 8 – 11
- Mesoscribe Technologies, Inc., Novel High Temperature Ceramic Sensors
- Rolls-Royce Corporation, Testing of Production Metallic and Prototype Advanced Composite Sandwich Structure Fan Cases
- NAVAIR, 2009 Lakehurst Engine Test
- DOE - NETL Pittsburgh, Laser Heat Flux Testing of TBC Overlay Coatings
- Siemens Energy Inc., Thermal Barrier Coatings High Heat Flux Testing, Dev. & Life Prediction
- DemVal Inc., Advanced Thermal Barrier Coating Systems for F100 Engine
- Maverick Corporation, Low-Cost Fabrication of High Temperature Composites
- Sulzer Metco (US) Inc, Evaluation of Sulzer Metco Processed Low Conductivity Thermal Barrier Coating (TBC) Systems
- Rolls-Royce NA Technologies, Materials Selection and Preliminary Component Design
- USAF AFRL, SiC/SiC Turbine Airfoil Material
- Boeing Company, Damage Prediction
- DOE/Sandia National Laboratories, Peridynamic Theory and Computational Modeling
- Aerion, Supersonic Boundary Layer Transition Prediction / Flight Test

Partnership:
Gulfstream Aerospace

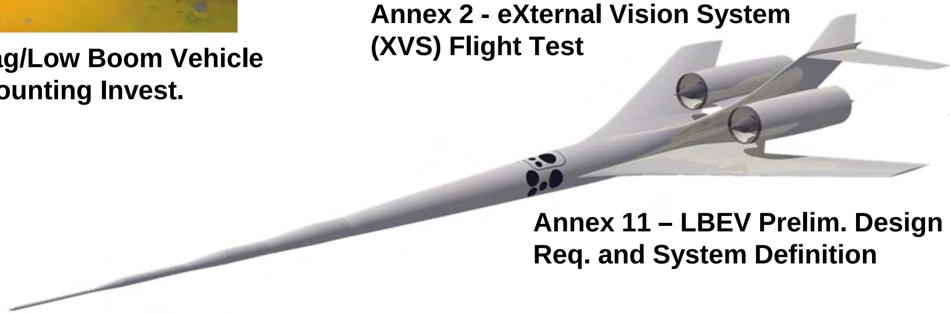
- Effective Space Act approach to pursue Supersonic collaborations with GAC across all 4 Aero Centers
- Expertise and resources are leveraged and shared in pursuit of the required tools and technologies for a Low Boom Experimental Vehicle (LBEV)

Annex 5 – Low Drag/Low Boom Vehicle Design & Model Mounting Invest.

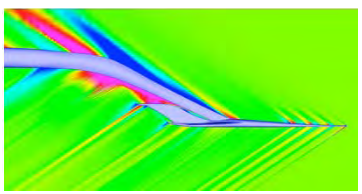
Annex 2 - eXternal Vision System (XVS) Flight Test



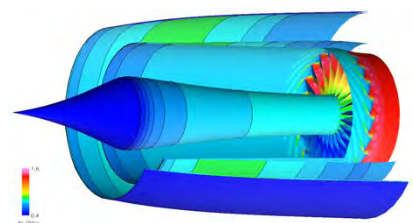
Annex 7 – MDAO of Bypass Flowpath in a Supersonic Prop. System



Annex 11 – LBEV Prelim. Design Req. and System Definition



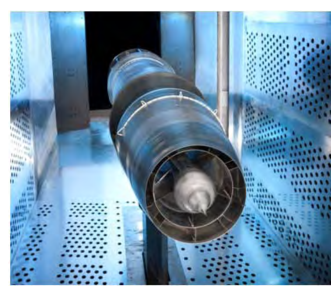
Annex 9 – Computational Design Studies for Low-boom Aircraft



Annex 6 – Coupled Analysis of Supersonic Low Boom Inlet & Fan

Annex 4 –Human Response to Rattles & Booms

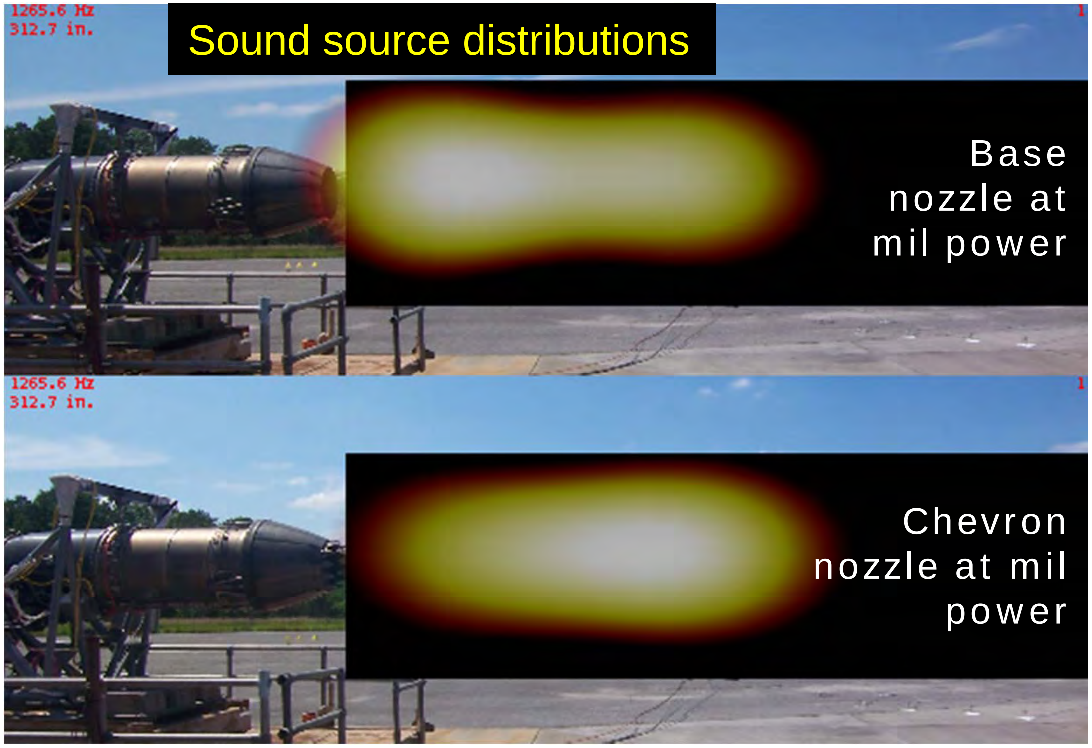
Annex 8 - Sonic Booms on Big Structures



Annex 10 – Test of a Low-Boom External Comp Supersonic Inlet

Partnership: NASA/Navy/GE F-404 jet noise test

- NASA 48-microphone phased array deployed by NASA Glenn researchers at Navy’s Lakehurst engine test stand in July 2009.
- Document acoustic impact of new chevrons on F/A-18’s General Electric F-404 engine, addressing noise load on Navy carrier personnel.
- Compared modification of sound field with that found in NASA model scale chevron nozzle tests conducted at NASA GRC also in collaboration with GE and Navy.



Research Dissemination: FY09-10 SUP Publications Summary

229 Publications

- 68 Peer-reviewed (49 NASA, 19 NRA)
- 135 Conference (85 NASA, 50 NRA)
- 15 NASA Reports
- 11 Other Publications
  - Contractor Reports
  - Dissertations
  - Books

75 Presentations

- Workshops
- Overviews
- Invited

Journals

- AIAA Journal (9)
- Int'l (4)
- J. of Propulsion & Power (3)
- ASME J. of Fluids Engineering (2)
- Procedia Engineering (2)
- Applied Physics Letters (2)
- Acta Materialia (2)
- J. American Ceramic Society (2)
- 31 Other Journals (1 each)

FY10 -11 Project Bibliography will be included on Meeting DVD

Upcoming Activities in Supersonics

- FY 11 APG Milestone – MDAO for Cruise Efficiency & Boom
- Boom & Drag Prediction/Design invited session, AIAA Applied Aero Conf, June 2011
- N+2 System Validation Testing at ARC 9x7 (Boeing/LM/NASA)
- Inlet bleed modeling experiments to support advanced inlet design tools
- Demonstrate adv. engine turbine EBC feasibility & durability for SiC/SiC CMC airfoils
- Demonstrate the viability of a low density/high temp. shape memory alloy
- Complete validation of RANS- & LES-based noise prediction codes
- Testing of Low Noise Nozzle Concepts (GE & RRLW)
- Flametube Testing of RR/GE/UTRC Low Emissions Concepts (in progress)
- Community response and operational effects flight experiments (NRA partners)

Summary

- The Supersonic Project is developing tools and technologies for the broad spectrum of supersonic flight with a focus on overcoming the barriers to civil aircraft, particularly overland supersonic cruise
- Our goals and technology portfolio are relevant to the above strategy and NASA and National goals
- Organization by technical challenges inspires innovative solutions at the seams between traditional research disciplines
- The project has defined a high quality research portfolio that emphasizes effective partnering of in-house, funded and cooperative elements
- The project's research is being broadly disseminated and applied by partners
- The project is executing well, according to a plan that is adaptable and changes in response to knowledge gained and other valued input

Supersonics Technical Sessions

- Tuesday PM
  - Technology Challenge Overviews (15 minute presentations)
- Wednesday AM
  - Lightweight, Durable Engines
  - Lightweight, Durable Airframes
  - Aeroservoelasticity
- Wednesday PM
  - Sonic Boom Modeling
  - Airport Noise
  - Feedback Session

    (Open Forum 1 hr)
- Thursday AM
  - Cruise Efficiency - Airframe
  - Cruise Efficiency - Propulsion
  - Flight Research & Validation
- Thursday PM
  - Systems Integration and Assessment
  - High Altitude Emissions

Join us in the Ambassador Ballroom one level down

Thank you!

Next Speaker: Dr. Jim Pittman, PM for Hypersonics